REDUCTION IN PARAMETER OF CONCERN LOADINGS DUE TO AGRICULTURAL DRAINAGE

(Actions 1, 10, 11, 12, 13, 14, 15, 16, 32B)

Goal

The goal of these actions is to maintain or improve water quality in the Sacramento-San Joaquin Delta (Delta) so that all beneficial uses are protected (e. g. municipal, industrial and agricultural water supply, recreation, fish and wildlife).

Objective

The objective of these actions is to reduce the loading and/or concentration of water quality parameters of concern attributable to AGRICULTURAL DRAINAGE within the Sacramento and San Joaquin river basins, Delta, and Suisun Marsh.

Geographic Scope

The geographic scope is defined as all of the following:

- areas within the Delta
- areas outside of the Delta in which biological resources that use the Delta are impacted
- areas outside of the Delta that are significant source areas for parameters of concern in the Delta

Thus, the Sacramento River above Red Bluff Diversion Dam would be in-scope with respect to the impact of metals concentrations and anadromous fish, but out of scope with respect to impacts on organisms unrelated to Delta biological resources. Also, Salt Slough is in-scope as a significant source of salt and trace element loading to the Delta.

Agricultural drainage sources within the geographic scope will be discussed in four categories. The land areas associated with these categories are summarized on Figure 1, and the areas and types of drainage are the following:

1. **San Joaquin Valley subsurface drainage.** Includes subsurface drainage from lands south of the Delta whose subsurface drainage outlet is a tributary to the Delta, as shown on Figure 2.
2. **San Joaquin Valley surface drainage.** Includes surface drainage from lands south of the Delta whose surface drainage outlet is a tributary to the Delta, as shown on Figure 2.
3. **Delta drainage.** Includes surface and subsurface drainage from lands in the Delta, as shown on Figure 3.
4. **Sacramento Valley surface drainage.** Includes surface drainage from lands north of the Delta whose surface drainage outlet is a tributary to the Delta, as shown on Figure 4.

Parameters of Concern Attributable to Agricultural Drainage

A number of agricultural water quality parameters of concern were identified for agricultural, ecological, and municipal water use. Those for which agricultural drainage is a major source are as

follows:

- Boron
- Copper
- Selenium
- Carbofuran
- Chlorpyrifos
- Chlordane
- Diazinon
- DDT
- PCB
- Toxaphene
- Ammonia
- Bromide
- Chloride
- Sodium
- SAR
- Salinity
- Nitrate
- Pathogens
- pH
- TDS
- Turbidity
- TOC

Estimated Parameter of Concern Loadings Due to Agricultural Drainage

When evaluating water quality, it is helpful to make a distinction between surface and subsurface drainage:

Surface drainage: During rainfall or irrigation, some proportion of water may run off of the land and enter surface drainage ditches and other water bodies. This runoff is surface drainage. Constituents of surface drainage may include substances dissolved in rain or irrigation water when it arrives at a field, plus substances dissolved in the water as it flows across the field, plus substances sorbed onto material (soil and surface litter) that become suspended in the flowing water. To varying degrees, ***pesticides and nutrients*** are sorbed onto solid materials. On Delta organic soils, organic material (***TOC***) can be suspended or dissolved in runoff, or dissolved in subsurface drainage. The quality of surface drainage depends largely on the amount of suspended material. To help identify surface drainage sources, it is useful to delineate the ***surface drainage area that flows to a water body***.

Subsurface drainage: To grow crops, some lands must be artificially drained to lower shallow groundwater levels. Shallow groundwater may seep into perforated, subsurface drain pipes or into intermittent field ditches, and flow to collection ditches and ultimately to other water bodies. Shallow groundwater contains dissolved constituents that may have migrated laterally to the area, that have been dissolved from local soil minerals, and that are applied with irrigation water. Solutes concentrate in shallow groundwater when plants are grown, since plants generally absorb more water

than solutes. Subsurface drainage water, therefore, can contain relatively high concentrations of ***dissolved trace elements, other salts, and organic compounds (TOC)***. These concentrations may become more problematic when subsurface drainage is stored and allowed to evapo-concentrate. To identify subsurface drainage sources, it is useful to identify areas meeting the following conditions:

- shallow groundwater within the root zone
- artificial subsurface drainage installed and functioning
- subsurface drainage conveyed to the water body in question
- constituent concentrations in shallow groundwater high relative to levels of concern

Loads of parameters of concern differ broadly among the four agricultural drainage source areas cited above. A general description follows. Table 1 provides a list of potentially useful data resources that have been identified and will need to be more fully exploited as detailed data is developed for specific CALFED actions. The data presented here are preliminary and intended for discussion. **This is not a definitive description of agricultural drainage sources. Such a description will require much more intensive exploitation of existing data, and perhaps some new data development.**

1. **San Joaquin Valley subsurface drainage.** Although considerable areas of the Sacramento Valley have relatively high groundwater, artificial subsurface drainage is not widespread, and little attention has been given to characterizing its quality. Therefore, the focus of subsurface drainage discussions in this document will be in the San Joaquin Valley, where data is more abundant, problems are better defined, and remedial actions have been more extensively studied. Naturally saline lands and geologic sources of trace elements, notably selenium, arsenic, and molybdenum, characterize some areas with artificial subsurface drainage in the San Joaquin Valley. Because of this, some of the subsurface drainage systems no longer discharge to water bodies tributary to the Delta. A Delta water quality data base was developed by the Agricultural Water Quality Subteam. Points for which data were collected (from existing DWR and USBR sources) are shown on Figure 5. Data from this database is briefly summarized in that team's report, and the database is available to support further study of constituents related to subsurface drainage.

   The geographic extent of the area with problem subsurface drainage corresponds to areas that meet the following conditions:

   - Shallow groundwater within the crop root zone during the growing season, so that subsurface drainage collected and flows to Delta. The extent of shallow groundwater in this area is shown on Figure 6.
   - Salinity and/or selenium concentration of the shallow groundwater, and therefore subsurface drainage is high. Concentrations of these parameters in shallow groundwater within the area are shown on Figures 7 (salinity) and 8 (selenium concentration).

   Figure 9 shows the relative salt and selenium loads to and in the San Joaquin River at a number of points during a low-flow period. Note that these concentrations are also influenced by changes in water management practices in the region, so that these data are illustrative. Nevertheless, they illustrate the large proportion of the San Joaquin River's selenium and salt loads that entered the river via Mud and Salt sloughs.

2. ***Delta drainage.*** Drainage outlets within the Delta are shown on Figure 10. Soils of the Delta can have high organic matter contents, resulting in elevated levels of TOC in drainage. Also, drainage volumes are considerable, due to the low elevation of irrigated lands, many below the level of adjacent water bodies.

3. **Sacramento Valley and San Joaquin Valley surface drainage.** Surface drainage from irrigated land within this area flows to the Delta, and to other water bodies within the geographic scope. Pesticide sources have not been mapped in detail as yet. Surface drainage volumes from the Sacramento Valley are large, partly owing to the nearly 500,000 acres of rice that is flood irrigated in the area. Existing source control programs in the Sacramento Valley will be discussed in the next section.

Water Quality Problem Areas for Parameters of Concern

An initial summary of water quality problems in the region was presented by the Central Valley Regional Water Quality Control Board, and are shown on Figure 11. Although not restricted to CALFED parameters of concern for agricultural drainage, this summary does indicate some of the major, drainage related water quality problems that need to be addressed. The CALFED Agricultural Water Quality Subteam Report also includes summary data from a complex of water quality sampling stations. Unfortunately, a number of the parameters of concern are not included among the data collected at these stations. Nevertheless, this information, and the water quality database discussed in the same report, will help define areas and timing when of agricultural drainage's impact on water quality.

In general, Figure 11 shows that pesticides, including certain that are currently in use and some that are not, are considered problems throughout the three defined agricultural drainage source areas. In the San Joaquin drainage source area (mainstem San Joaquin River and Mud Slough), selenium and salinity (TDS) are cited as problems. Only in the mainstem San Joaquin River is another drainage related parameter, specifically boron, cited as a problem.

Current Programs

Some of the programs, practices, and regulations that influence agricultural drainage water quality include the following:

- **The San Joaquin Valley Drainage Implementation Program,** Multi-agency
- **The Drainage Program and its constituent programs,** Department of Water Resources
- **The Rice Herbicide Program,** Initiated by the California Department of Pesticide Regulation
- **Federal and state restrictions** on the use and handling of pesticides.
- **Water contract requirements**
- **Voluntary implementation** of IPM and BMP's to reduce farming costs and pollution sources.
- **Local district programs,** such as Westlands Water District's Groundwater Management Plan
- **Habitat Enhancement Landowner Program,** Western Growers Association.

Other recommendations include those developed by a series of Technical Advisory Committees to the California State Water Resources Control Board, covering the following areas:

- Irrigated agriculture
- Pesticide management
- Dairy and feedlot management
- Rangeland management
- Plant nutrient management

Three current programs will be discussed briefly:

The Drainage Reduction Program, a sub-program of the Drainage Program at the Department of Water Resources: This program examined the potential of a number of technologies and management tools to reduce subsurface agricultural drainage. Examples include improved furrow irrigation, shallow groundwater management, tiered water pricing, irrigation efficiency, and emerging irrigation technologies. The Supplemental Information section provides a summary of funded projects.

The Rice Herbicide Program, initiated by the California Department of Pesticide Regulation in 1984. The herbicides are not included among the parameters of concern, but this may be largely due to this program and the efforts made by the rice industry to reduce herbicide concentration in surface drainage. This program included establishment of rice herbicide performance goals for the Colusa Basin Drain and the Sacramento River. Holding times for rice irrigation water after herbicide application were specified, and the rice industry installed a variety of innovative irrigation return flow control systems.

Habitat Enhancement Landowner Program, Western Growers Association, California Farm Bureau Federation, and California Cattlemen Association. Under this program, landowner/growers implement habitat enhancement on their property, and receive a general incidental take permit to protect them from Endangered Species Act enforcement that might result from the increased wildlife presence in the enhanced habitat. With regard to drainage, habitat enhancement can play an important role, if it is designed to do so. For example, filter, or buffer strips (land with relatively dense vegetative cover) can remove sediment and associated parameters of concern from runoff, and wetlands allow for sediment settling and decomposition of organic constituents, and immobilization or uptake of other parameters of concern.

Effectiveness of Current Programs

The Drainage Reduction Program. A series of reports provide a substantial basis for evaluating the tested technologies and management tools. These reports have and will help support large scale implementation, and should be considered a key resource as CALFED develops projects toward implementation.

The Rice Herbicide Program. Resulting reductions in rice herbicide concentrations were dramatic, and generally in compliance with increasingly stringent performance goals. The program, context, and results are described in the Supplemental Information section.

Habitat Enhancement Landowner Program, This program is in the early stages of development, but has wide support and substantial promise. If habitat enhancement measures that reduce parameter of concern concentrations in agricultural drainage are a focus of the program, the program should

help to considerably improve agricultural surface drainage management.

Priority Actions to Reduce Impacts of Agricultural Drainage

Action 1: Control the timing of agricultural drainage to coincide with periods when dilution flow is sufficient to achieve CALFED water quality target concentrations.

Expected Benefits: Reductions in loadings of parameters of concern associated with agricultural drainage to waters within the geographic scope.

Other Considerations:

- This also implies temporary retention (storage) of drainage in source areas.
- Drainage from areas producing high concentrations of parameters of concern would be targeted. Subsurface drainage return flow with high selenium concentrations is one example.
- Coordinate effort with existing programs.
- Discharge from storage would be problematic in dry years, when periods of high flow would not occur.
- Discharge would be limited by Vernalis standards for water quality.
- Kesterson Reservoir was conceived for this purpose.

Action 11: Implement additional agricultural source control for water quality parameters of concern found in agricultural surface and sub-surface drainage. Implementation may include incentives and/or enforcement of existing regulations.

Expected Benefits: Reductions in loadings of parameters of concern associated with agricultural drainage to waters within the geographic scope.

Other Considerations:

- Surface and subsurface drainage mobilize different constituents, and must be treated separately. For example, pesticide and nutrient loads are principally in surface drainage, whereas salinity and trace elements (from west side San Joaquin Valley lands), and TOC (from in-Delta lands) are principally in subsurface drainage.
- Areas producing high concentrations of parameters of concern would be targeted. Subsurface drainage return flow with high selenium concentrations is one example.
- Implementation strategy should differ between parameters for which load is principal concern (salinity), relative to those for which concentrations are the principal concern (pesticides and trace elements).
- Concentrate on load, considering EWMP's when they can be cost-effectively related to load reduction. A reduction in drainage volume without reduction in load will result in higher concentrations. However, Ayers and Shrale (Irrigation efficiency and regional subsurface drain flow in the west side of the San Joaquin Valley, no date) reported that the total load of Selenium and Borion in drainage water was proportional to flow.
- Incentives or enforcement of existing regulations are included, although existing regulations appear to be adequately enforced.
- Source control could be effected by measures such as modification of field drainage systems; pest, irrigation, and tailwater management to reduce pesticide loads; BMP's to reduce pesticide loads; and water conservation where it does not conflict with sustainable production (e.g., on

lands that have no drainage problem, but whose shallow groundwater flows to neighboring, drainage affected lands).
- Coordinate effort with existing programs.

Action 13: Provide incentives to fallow or retire land that is a major source of water quality parameters of concern. Landowner participation should be voluntary and by compensated purchase or lease payment.

Expected Benefits: Reductions in loadings of parameters of concern associated with agricultural drainage to waters within the geographic scope.

Other Considerations:
- Marginally productive land to be targeted as a matter of priority, since removal of this land from production would have the least impact on local socioeconomic conditions and would likely be more cost effective.
- Marginal benefit would be greater, marginal cost lower, for fallowing of land during drought years.
- Targeted parameters would be principally trace elements and TOC.
- Coordinate effort with existing programs.

Action 32B: Implement additional agricultural source control for water quality parameters of concern found in agricultural surface and sub-surface drainage. Implementation may include provision of incentives for pesticide users to increase implementation of best management practices (BMPs) including integrated pest management (IPM) to reduce pesticide loads and concentrations from agricultural drainage.

Expected Benefits: Reductions in loadings of pesticides of concern associated with agricultural drainage to waters within the geographic scope

Other Considerations:
- IPM technology is expensive to develop, therefore priority would be increased implementation of existing technology that reduces pesticide loading.
- Incentives might serve to help farmers transition into technologies that involve significant startup costs or risks.
- In the medium term, IPM could reduce production costs for some farms.
- Coordinate effort with existing programs.

Other Actions to Reduce Impacts of Agricultural Drainage

Action 10: This action has been combined with Action 11.

Action 12: Improve source irrigation water quality in sub-surface drainage source areas. All things being equal, higher quality irrigation water will result in better quality drainage.

Expected Benefits: Reductions in loadings of salinity and trace elements associated with agricultural drainage to waters within the geographic scope.

Other Considerations:

- Due to its large volume, water quality for irrigation is highly constrained, so that programs to improve irrigation water quality might not be feasible.
- This action could be considered as a "no-action" alternative to actions that would result in significant degradation of irrigation water quality.

Action 14: Reduce the loadings of water quality parameters of concern entering the Delta and San Joaquin tributaries by concentrating and disposing of agricultural sub-surface drainage in evaporation ponds in the San Joaquin Valley.

Expected Benefits: Reductions in loadings of salinity and trace elements associated with agricultural drainage to waters within the geographic scope.

Other Considerations:

- Wildlife hazards are associated with concentrated subsurface drainage.
- Disposal of evaporite salts is environmentally problematic and costly.
- Construction and land costs of ponds are considerable.
- Concentrate effort in trace-element source areas.

Action 15: Reduce the loadings of water quality parameters of concern entering the Delta and its tributaries by treating agricultural surface drainage and/or Delta agricultural sub-surface drainage in constructed wetlands.

Expected Benefits:

- Reductions in loadings of TOC associated with Delta agricultural drainage.
- Reductions in pesticides concentrations in treated surface drainage.

Other Considerations:

- Reduction in TOC in Delta wetlands may or may not be feasible.
- Size and cost of constructed wetlands might have to be large to have the desired impact.

Action 16: Reduce the loadings of water quality parameters of concern entering the Delta and San Joaquin tributaries by treating a significant portion of San Joaquin agricultural sub-surface drainage by reverse osmosis or other means.

Expected Benefits:

- Reductions in loadings of salt and trace metals associated with agricultural drainage to waters

within the geographic scope.
- Dilution flow available due to decreased diversion for irrigation.

Other Considerations:
- Treated water would likely be reused locally, but may or may not replace other water supply.
- Treatment by reverse osmosis or other means might not be cost effective.

Compatibility of Actions with On-Going Programs

In general, on-going programs fall under one or more of the named actions. One of the primary challenges facing action implementation will be regulatory compliance. Some of the existing programs already have the support of regulatory agencies, and should therefore provide an excellent opportunity for synergy with respect to support and expansion of promising, proven programs, and for informed development and favorable regulatory consideration and approval of proposed actions.

Potential Linkages of Actions to other CALFED Common Program Components

Actions related to agricultural drainage management, reduction, and reuse are linked to other CALFED common program components in a myriad of ways. Some of these linkages are noted below. As individual actions are developed for evaluation and implementation, the linkage aspect of each will have to be addressed in more detail.

- The actions related to agricultural drainage will result in reductions in parameters of concern. Trace elements and pesticides are specifically a concern for sensitive species within the geographic scope. **Linkage: Ecosystem Restoration.**
- Agricultural subsurface drainage volume and quality are tightly linked to water supply quality and sufficiency, and therefore to the Water Use Efficiency, and to the Storage and Conveyance components. These relationships are discussed in detail, especially for salinity, in the CALFED Agricultural Water Quality Subteam report. In general, when water is scarce enough to require additional groundwater pumping, subsurface drainage volume and concentration from a given field increase. **Linkage: all but Levee Stability and Maintenance.**
- Some of the actions propose temporary detention of subsurface drainage, for later, more timely release into the Delta. The water would be retained either in above-ground storage, or below ground in the unsaturated soil and shallow groundwater. **Linkage: all but Levee Stability and Maintenance.**
- Focused habitat enhancement is one of the ways that surface drainage parameter loads might be reduced. **Linkage: Ecosystem Restoration.**
- A number of the source control measures are associated with careful, even sparing application of irrigation water. These measures would significantly reduce the volume applied water, and of surface and subsurface drainage, and thereby the flows in drainage facilities. **Linkage: all but Levee Stability and Maintenance.**
- Treatment of drainage in wetlands, filter strips, and settling basins would require that these facilities be created or enhanced for this function. In the Delta, levee facilities would have to be considered when implementing these measures. **Linkage: Levee Stability and**

Maintenance.